AECOM

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March 27, 2009

William Lindner
New Jersey Department of Environmental Protection
Brownfield Remediation & Reuse Element
401 East State Street, 6th Floor
PO Box 028
Trenton, New Jersey 08625-028

Subject: Ingersoll Rand – Phillipsburg, New Jersey

Dear Mr. Lindner:

Thank you for taking the time to meet with us on February 5, 2009 to discuss our progress on groundwater investigation activities that have been conducted at the former Ingersoll Rand site in Phillipsburg, New Jersey. Based on our conversation, there were several items which were left for further discussion either pending additional information to be provided, or after NJDEP could further review available information.

To facilitate NJDEP's internal discussions as well as provide you with the information promised, AECOM (formerly ENSR) has presented the key topics from our February 5th meeting and "open issues" below (*in italics*) along with additional facts to either provide additional detail or support Ingersoll Rand's position.

We are looking forward to a follow-up meeting and appreciate the chance to discuss opportunities for bringing the site to the end of the investigative phase and into the remedial action phase.

The remainder of this letter is organized with a general topic (underlined) followed by our understanding of NJDEP's position or request (in italics), and our presentation of additional information or discussion points (indented normal text).

Residential Well Sampling:

Ingersoll Rand asked for NJDEP guidance regarding when Ingersoll Rand's involvement in the residential well sampling and POET system maintenance could be phased out.

> AECOM understands that residential well sampling and POET maintenance should continue until contaminants of concern ("COCs") are no longer detected in the offsite residential wells that are the subject of ongoing sampling. NJDEP further agreed that less frequent sampling may be appropriate if COC concentrations stabilize over several sampling rounds.
>
> Ingersoll Rand agrees that continuation of the offsite potable well sampling is warranted and will keep NJDEP apprised of the results and trends in concentration, as appropriate.

Well Retrofits:

NJDEP commented that the retrofit of well MW6 sealed a zone where dissolved phase volatile organic compounds ("VOCs") were detected and installed the new well screen in a "clean" zone at the bottom of the well.

Ingersoll Rand was in verbal communication with the former NJDEP Case Manager during the retrofit of well MW6. It was agreed that the establishment of a "clean" zone for vertical delineation purposes was more important at this location than monitoring the known impacted zone. Lines of evidence, including a 72-hour aquifer pumping test, established that the impacted zone that was sealed with the well casing in MW6 could be monitored in the downgradient well MW35, which is located closer to the property boundary.

Regarding AECOM's plans to retrofit MW38, the NJDEP Case Geologist (David Froehlich) suggested that he would like to see the well deepened for vertical delineation near the southern site border and be involved in the decision of which depth interval should be screened.

AECOM consulted with the NJDEP Case Manager during the Well MW38 retrofit. Information on this upgrade will be included in a subsequent report to NJDEP.

Former Potable Wells:

As discussed in our January 12, 2009 letter to NJDEP, the three former potable water supply wells at the site (WW1, WW2, and WW3) are unsuitable for groundwater monitoring purposes and are proposed to be abandoned. The NJDEP Case Geologist (David Froehlich) expressed his interest in retaining and modifying well WW-3 as a deep groundwater monitoring well.

Ingersoll Rand had previously proposed using the three potable water wells for monitoring purposes. During a June 2005 meeting, NJDEP (Mr. R. Lux) cautioned that these wells may not be suitable or appropriate for groundwater monitoring and that the wells should be further evaluated before they would grant a request to use them for monitoring purposes. Based upon further evaluation of the wells as suggested by the NJDEP, AECOM concluded that the wells were not appropriate for monitoring, would be risky and expensive to retrofit, and the long open-hole sections of these wells should be sealed to prevent communication between impacted and non-impacted fracture zones.

Low levels of COCs were detected as deep as 757 feet in former water supply well WW3. The low levels of COCs detected at this depth likely result from downward flow within the open borehole of the well, rather than contamination detected in fractures at this depth. The chlorinated VOCs ("CVOCs") in this area are likely limited to the main facility area and do not appear to pose a danger to off-site receptors.

Mr. Froehlich also stated that he would like to evaluate the data collected in well WW3 and provide Ingersoll Rand with the zones that he is interested in monitoring in this well by the next groundwater status meeting tentatively scheduled for March/April 2009.

AECOM and Ingersoll Rand are open to discussing other potential options based upon Mr. Froehlich's review of the data. However, please also consider that well WW-3 is located beneath high-voltage power lines that must be de-energized each time that a drilling rig or service truck is used to work on the well. De-energizing these power lines shuts off the electrical power to the entire facility, thereby shutting down operations for the on-site businesses and tenants. In our opinion, despite low levels of impacts in WW3, it is the least likely candidate for retrofit and continued monitoring.

Groundwater Monitoring Issues:

Vertical delineation at well MW56 was discussed. NJDEP recalled that during well installation activities, impacted zones were identified at 175 and 276 feet below ground surface. These impacted fractures were sealed behind casing in MW56 and could not be included in future sampling and monitoring.

Well MW56 was installed as a vertical delineation well expressly for the purpose of continued monitoring of a deeper and un-impacted zone such that we may meet the vertical delineation requirements of the Technical Requirements for Site Remediation (see prior discussion). Ongoing groundwater sampling is conducted to monitor this unimpacted zone and identify whether COCs are migrating downward from the impacted zones identified at shallower depths.

NJDEP asked if the original pilot boring PH1 was still open and whether it could be retrofit to monitor one of the impacted zones identified during the testing and completion of well MW56.

As a compromise, Ingersoll Rand agrees to sample the PH1 borehole using PDBs during the April and October 2009 sampling events. However, we do not believe that monitoring of impacted zones in the center of the site provide data that would effect the long term monitored natural attenuation strategy we have proposed for addressing groundwater impacts across the site.

Regarding Ingersoll Rand's suggestion that sampling frequency be reduced to annual sampling and that several wells are removed from the sampling scope, NJDEP suggested that Ingersoll Rand provide a list of wells that are requested to be removed from the sampling plan.

We understand that NJDEP is amenable to reduced sampling frequency. A formal request to reduce the sampling frequency to annual sampling will be submitted to NJDEP in the near future. Regarding reduction in the number of wells sampled, much of the groundwater data collected during the semi-annual sampling events is becoming redundant after numerous years of sampling. In wells; i) where no impact has been reported for several years; or ii), have low hydraulic conductivity; and/or iii) do not appear hydraulically connected to other on-site wells, AECOM recommends that sampling of these wells be discontinued. A list of wells and a summary of the rationale for each is included as an attachment to this letter.

We propose concentrating the sampling program on impacted wells that will be monitored for the suggested natural attenuation remedy and delineation/sentinel wells to monitor potential migration of COCs.

Monitoring Metals Impacts in Groundwater:

The NJDEP Case Geologist requested that additional groundwater monitoring be conducted to assess potential metals impacts. He suggested that additional low-flow samples be collected for metals analysis from the top of the water column to see if near surface soils are leaching metals into the groundwater at the water table.

In the past, between 1988 and 2004, Ingersoll Rand collected metals samples via conventional sampling methods in 37 wells. In addition, low flow sampling was completed during two to four rounds at each of 29 wells between 2003 and 2007. Results of sampling (requested by NJDEP) in October 2004 (19 wells) and April 2006 (22 wells) to resolve the metals issue in groundwater revealed that no metals exceeded the GWQS for these two sampling events.

In a June 20, 2005 meeting, NJDEP agreed that there were no remaining metals impacts in groundwater and that the removal of metals from the sampling program was warranted. NJDEP again requested a similar assessment of metals during the April 5, 2006 groundwater meeting. At this meeting, NJDEP requested additional groundwater samples from the "small (micro) fractures" intersecting the wellbore rather than just the hydraulically conductive fractures.

Low flow sampling for metals was then conducted in two monitoring wells in November 2006 and April 2007, per NJDEP request, to assess potential vertical stratification of metals and close the issue of metals in groundwater. Groundwater samples were collected and analyzed for Priority Pollutant ("PP") metals in wells MW36 (120 feet and 144 feet deep) and MW39 (102 feet and 133 feet deep). Results did not indicate any metals impacts.

Low flow sampling was generally targeted to hydraulically conductive fractures, the most likely fractures available for conducting the sampling correctly. Based upon the characteristics of the fractured karst aquifer, the numerous on-site wells, and the hundreds of fractures logged during geophysical investigations at the site, AECOM felt that sampling numerous fractures in each well was not scientifically feasible or economically viable. Volume averaged sampling in conjunction with selective low flow sampling of the most viable fractures in the wells provides a technically sound strategy for assessing metals impacts in groundwater at the site.

Further, research published in the journal *"Ground Water Monitoring & Remediation"* reports that the pump location during low-flow sampling is not the determining factor of where the sample is actually collected (Varljen, et. al., 2006). The report suggests that groundwater from the most hydraulically conductive zones intersecting the wellbore will be preferentially drawn to the pump. Therefore, pump placement at less hydraulically conductive fractures will not necessarily draw water from these less conductive zones. Groundwater collected during low-flow sampling will still come from the most hydraulically conductive zones in the well and will be drawn vertically to the pump from within the water column in the well bore or casing, which is infinitely more conductive than the formation.

<u>MW31 Optical Televiewer Log:</u>

NJDEP Case Geologist noted that staining was observed near a group of fractures detected in the optical televiewer log for well MW31, located on the west side of the former manufacturing facility. NJDEP requested that a groundwater sample be collected from the stained fracture zones via a passive diffusion bag ("PDB") sampler to assess the nature of the staining.

In effort to resolve this issue, Ingersoll Rand will collect one VOC sample near the stained fractures in well MW31 during the upcoming semi-annual sampling event scheduled for April 2009.

<u>Dry Well AOC Monitoring Well:</u>

NJDEP recalled that a monitoring well was proposed by Ingersoll Rand near the Dry Well Area of Concern ("AOC") in the Main Facility Area and suggested that it may be an appropriate location for source monitoring.

A monitoring well was proposed in 2005 at the Dry Well AOC to comply with the Technical Requirements for Site Remediation for source monitoring. This proposal was made prior to the completion of the geologic conceptual model presented in the 2004 Annual Groundwater Monitoring Report. Based on the fact that groundwater in this area is found in the bedrock ranging in depth from about 85 to 115 feet below ground surface and bedrock is present at approximately 20 feet deep, it was determined that potential source material entering the bedrock from the dry well would have moved down dip toward the southeast along the bedrock surface and shallow fractures until it encountered the water table. It is AECOM's opinion that well RW16 (located hydraulically downgradient) is appropriate for assessing the impact from the drywell AOC and does not recommend an additional well at the dry well location.

Interim remedial activities were conducted in the dry well area to remove material from inside the dry well structure. This was reported to the NJDEP in the Q1-2006 progress report on May 2, 2006.

<u>Courtyard Source Area and Monitoring Well:</u>

NJDEP discussed the CVOC impacts identified in soil in the courtyard area within the Main Facility and suggested that soil remediation may be appropriate in this AOC. Additionally, Mr. Froehlich suggested that a source area monitoring well be installed adjacent to (within 10 feet) the impacted soils in the courtyard to monitor potential dissolved-phase VOCs. Similar concerns were expressed related to the petroleum hydrocarbons in soil throughout the courtyard area.

Limited removal of CVOC-impacted soil in the courtyard was proposed in the 2005 SI/RI/RAWP, which remains in NJDEP review.

Petroleum impacted soils were detected across much of the courtyard area and may have been a source of groundwater impacts in the past. However, four wells were installed as "sumps" in effort to determine if petroleum could be recovered from these soils. To date, no petroleum has been recovered. It is AECOM's opinion that the courtyard soils are no longer providing a source for groundwater impacts.

Based on the above as well as the technical impracticality of excavation – there are significant subsurface obstructions and utilities as well as proximity to building foundations – excavation was not considered the best option. As reported in the 2005 SI/RI/RAWP, petroleum impacts in this area could be sufficiently addressed with the existing concrete cap to prevent direct contact as well as infiltration and the potential for ongoing contribution to groundwater impacts.

Regarding the placement of a source monitoring well near the CVOC impacted soil, we considered the bedrock morphology and believe that any potential source contribution would have been directed southeastward (down dip) until encountering the groundwater surface. Well RW9 sufficiently characterizes the potential source contribution of CVOC impacted soil in the courtyard. Based on these reasons, we do not recommend the installation of an additional monitoring well.

Oil/Water Separator Building:

NJDEP recalled that the soils beneath the oil/water separator building might be a potential source area based upon the petroleum odors evident within the building.

As NJDEP is aware, Ingersoll Rand is in the process of upgrading the groundwater treatment system to meet the recently changed effluent limitations. As part of the upgrade, the existing oil water separators were removed. During the removal of the tanks, approximately one-foot of visibly impacted soil was also removed. Following soil excavation, the subgrade space in the building will be backfilled to match surrounding ground elevation.

Additionally, it is anticipated that much of the petroleum odor in the structure was related to the oil/water separators rather than petroleum vapors rising from the soil. Regardless, a vapor barrier will be installed during the backfilling of the subgrade space to prevent the potential for future vapor intrusion.

Delineation Wells:

NJDEP stated that, in addition to the proposed offsite delineation well southwest of MW34, an additional monitoring well should also be installed southwest of MW35, near or beyond the southwestern site boundary. Mr. Froehlich also mentioned that a delineation well along the southern property boundary, between of MW38 and MW49 may also be appropriate.

Ingersoll Rand has been negotiating with the Town of Phillipsburg to install a well in one of the streets southwest of well MW34. Access issues have not been resolved with the Town yet. Ingersoll Rand agrees that a delineation well southwest of MW35 is appropriate and will work with the Town to gain access permission for its installation in Green Street.

Regarding additional wells in the southern and southeastern portions of the property, we do not agree that adding monitoring locations in these areas will advance the investigation goals nor will the data generated from such wells be likely to change the remedial approach or provide additional information to reduce risk to the offsite properties.

As additional support, well MW-38 was recently redrilled and retrofit to open the collapsed section of the well. Analytical results indicated that bromodichloromethane was detected at concentrations greater than the GWQS. However, bromodichloromethane is a disinfection byproduct of water treatment and is not a contaminant of concern at the former Ingersoll Rand facility. Although dibromochloromethane, chloroform, and xylene were also detected in MW38, they were all much less than the GWQS.

Additionally, the four residences on Lock Street – located southeast of well MW38 – have low concentrations of trichloroethylene. These wells are monitored on a regular basis and serve as the southernmost delineation of COC impacts. Monitoring wells MW38 and MW49 near the southeastern property boundary have not reported COCs greater than the GWQS.

Based upon the lack of COCs detected in wells MW38 and MW49 and the ongoing sampling at the residential wells, Ingersoll Rand sees no technical reason to install additional delineation wells in the southeastern portion of the site..

<u>Vapor Intrusion:</u>

NJDEP indicated that vapor intrusion ("VI") issues will need to be addressed on and off-site and asked Ingersoll Rand to resubmit the 481Lock Street VI information for their review. DEP also suggested that VI issues will need to be addressed further as the investigative phase of the project nears completion.

Attached, please find the VI assessment and modeling conducted to support offsite VI concerns at 481 Lock Street. Note that Ingersoll Rand also conducted an indoor air quality investigation in several on-site buildings and – as reported in the 2005 *Main Facility Area SI/RI/RAWP* – no results exceeded the OSHA PELs for the onsite industrial facilities.

<u>Remedial Action:</u>

NJDEP and Ingersoll Rand agreed that the groundwater investigation phase of the project is nearing completion. However, NJDEP indicated that active remediation – for dissolved phase CVOCs – may be appropriate in some areas of the site.

Ingersoll Rand continues to assert that monitored natural attenuation ("MNA") is the most appropriate remedial action for groundwater impacts at the site based on the absence of DNAPL, the low concentrations of COCs, and the complex hydrogeologic setting. Ingersoll Rand proposed MNA and the establishment of a groundwater classification exception area ("CEA") in a January 2007 Annual Groundwater Monitoring Report. Data collected during the many years of groundwater investigation and sampling coupled with an extensive evaluation of the data indicate that COC concentrations are declining and that natural attenuation is occurring. CVOC concentrations in the Main Facility area have declined an order of magnitude from the 10^2 µg/L levels reported in the *2004-2005* monitoring period to 10^1 µg/L levels reported in the most recent data from October 2008.

Ingersoll Rand continues to operate a dual phase groundwater and LNAPL extraction system in the Main Facility Area. COCs have not been detected in the groundwater extracted from this remediation system and do not appear to be related to the LNAPL. The complex hydrogeologic nature of the site makes it difficult and expensive to determine the location, volume, and frequency for successfully injecting or applying a remediation amendment to impacted fractures and/or groundwater flow paths to address the low-level CVOC impacts. Additionally, since impact to sensitive receptors is being controlled and

CVOC impacts are generally confined to the Main Facility area, active remedial measures are inappropriate for the dissolved phase impacts at the site.

Conclusion

We understand that NJDEP has planned an internal meeting to discuss the issues that were raised during our February 5, 2009 meeting and will schedule a follow-up meeting with Ingersoll Rand to more fully discuss NJDEP's position relating to the remaining issues. We look forward to this upcoming meeting and hope that the information presented in this letter provides some additional understanding of the complex conditions at the site and our proposed plan to address groundwater impacts across the site. In an effort to focus on those areas that NJDEP believes to be the most important, we request that NJDEP provide a summary agenda for the next meeting such that we may be prepared to discuss the most important issues in greater detail. It is our goal to come to an agreement with NJDEP that sets a clear endpoint for the investigation activities.

Please contact me via telephone or e-mail if you have any questions or concerns. We look forward to our next meeting.

Yours sincerely,

William D. Spronz

William Spronz
Senior Technical Specialist

G R Micalizio

Gregg Micalizio
Program Manager

cc: Dawn Horst (Ingersoll Rand Company)
Kevin Traynor (Preferred Unlimited, Inc.)
Gary Brown (RT Environmental)

Attachments:

Attachments

Ingersoll Rand Phillipsburg, New Jersey Site
Proposed Wells to Remove from Sampling Plan

AECOM recommends that the following 13 monitoring wells should be removed from the groundwater sampling program at the Ingersoll Rand Phillipsburg, New Jersey site and abandoned. We also recommend that semi-annual groundwater sampling be reduced to annual groundwater sampling.

Wells recommended for removal from the sampling plan and abandonment:

MW01 – All analytical results for MW01 during 2008 were non-detect. Historical sampling results from this well indicate that concentrations of VOCs have been generally below detectable limits since sampling began in this well in 1990. Therefore, AECOM recommends removing this well from the sampling plan.

MW02A – This well has reported low concentrations of VOCs below the NJDEP groundwater quality standards ("GWQS") since 2002. Well MW02A has a very low pumping rate and high drawdown indicating a low yield. It is likely that this well is not hydraulically connected to other wells at the site. AECOM recommends removing this well from the sampling plan.

MW13 – Analytical results for MW13 during 2008 were non-detect. As this is not a boundary well and exhibits only a moderate yield, AECOM recommends removing this well from the sampling plan.

MW24 – Analytical results for MW24 during 2008 were non-detect. Concentrations have been below laboratory reporting limits for multiple rounds at all sampled depths in this well. Based on this information, AECOM recommends removing this well from the sampling plan.

MW26 – Analytical results for MW26 during 2008 were non-detect. The well has a low yield, is located in the center of the site, and is not a boundary well. Therefore, AECOM recommends removing this well from the sampling plan.

MW27 – Analytical results for MW27 during 2008 were non-detect and the well has low yield. AECOM recommends removing this well from the sampling plan.

MW28A - VOCs have been historically non-detect in groundwater collected from well MW28A. This well is located in the center of the site and is not a boundary well. AECOM recommends removing this well from the sampling plan.

MW47 – Analytical results for MW47 during 2008 were non-detect and the well has a low yield. This well is a boundary well located along the northern boundary of the site but does not appear to be connected to areas exhibiting chlorinated impacts. Historical analytical results from this well report no detectable concentrations of VOCs. Therefore, AECOM recommends removing this well from the sampling plan.

MW48 – Analytical results for MW48 during 2008 were non-detect and the well has a low yield. This well is located in the cornfield, approximately 700 feet from the nearest neighboring well and does not appear to be hydraulically connected to areas with chlorinated impacts. Historical analytical results from this well report no detectable VOCs. Therefore, AECOM recommends removing this well from the sampling plan.

MW49 – Analytical results for MW49 during 2008 were non-detect. This well is a boundary well located along the eastern boundary of the site; however, does not appear hydraulically connected to areas of the site exhibiting chlorinated impacts. Historical analytical results from MW49 report no detectable concentrations of VOCs. Therefore, AECOM recommends removing this well from the regular sampling plan.

MW52 – Historically, no detectable levels of VOCs have been reported in groundwater collected from well MW52. This well is located in the center of the site has collapsed on its Teflon tether, preventing sampling at this time. MW52 is not a boundary well and AECOM recommends removing it from the sampling plan.

MW54 – Analytical results for MW54 during 2008 were non-detect and the well has a low yield. This well is located in the center of the site and historic sampling results report no detectable concentrations of VOCs. Therefore, AECOM recommends removing this well from the sampling plan.

RW10 - RW10 has a very low yield. Historical analytical results report that concentrations of VOCs have been below standards since October 2002 with little fluctuation over time. Therefore, AECOM recommends this well be removed from the sampling plan.

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December 18, 2007 via FedEx

Mr. Christopher Kanakis
Case Manager
New Jersey Department of Environmental Protection
Office of Brownfield Reuse
401 East State Street – 6th Floor
Trenton, New Jersey 08625-0426

Subject: Vapor Intrusion Modeling and Risk Evaluation at Residence located at 481 Lock Street, Phillipsburg, New Jersey
ISRA Case Number 2004306
ENSR Project Number 03710-176

Dear Mr. Kanakis,

On behalf of Ingersoll Rand, ENSR completed a screening-level vapor intrusion evaluation to assess the potential carcinogenic and noncarcinogenic risk associated with exposure to trichloroethene (TCE) in groundwater via the indoor air inhalation exposure pathway to off-site residents at 481 Lock Street, located beyond the southern property boundary of the former Ingersoll Rand Facility in Phillipsburg, New Jersey (site). A site location map is provided as Figure 1. As you are aware, TCE has been detected at this location at concentrations that slightly exceed the NJDEP groundwater quality standards (GWQS) and the groundwater screening levels (GWSL) for vapor intrusion. TCE concentrations in excess of the GWQS and GWSL have been delineated to the neighboring residences beyond the southern property boundary. Therefore, this screening-level assessment was conducted only for the residence at 481 Lock Street. Note that a point of entry treatment (POET) system has been installed at this residence to remove TCE concentrations from the water prior to use within the home.

Vapor Intrusion Modeling

ENSR utilized the Johnson & Ettinger (J&E) model in accordance with the NJDEP vapor intrusion guidance[1, 2] to complete a screening-level assessment of potential vapor intrusion at the 481 Lock Street residence. The modeling was conducted using the spreadsheets provided by NJDEP (http://www.nj.gov/dep/srp/guidance/vaporintrusion/njje.htm) to estimate the potential excess lifetime carcinogenic risk (ELCR) and noncarcinogenic hazard quotient (HQ) associated with inhaling TCE detected in groundwater that may potentially volatilize into indoor air for a residential scenario.

The J&E model is a screening-level model that uses many default conservative parameters, where site-specific modifications are confined to the most sensitive parameters. The “advanced” version of the

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[1] NJDEP. 2005. Vapor Intrusion Guidance. New Jersey Department of Environmental Protection (NJDEP). Site Remediation and Waste Management Program and the Division of Science, Research and Technology. October 2005.

[2] NJDEP. 2007. Generic Vapor Intrusion Screening Levels. NJDEP. [URL: http://www.state.nj.us/dep/srp/guidance/vaporintrusion/vig_tables.pdf. March 2007.

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J&E model was used for this evaluation. Default parameters recommended by NJDEP[3] were used where site-specific information was not available. Equations and non-New Jersey-specific parameters required for the implementation of this model are provided in the *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings*[4].

The following site-specific information was used in the J&E modeling:

- The maximum reported TCE concentration at the potable well located at 481 Lock Street (1.1 ug/L) was used as the model input to provide a "worst case" result.

- The depth to water at 481 Lock Street is approximately 10 feet below ground surface (ft bgs). Therefore, a depth of 304.8 cm (10 feet below ground surface (ft bgs)) was entered into the model.

- Silty clay was selected as the soil type that most closely represents the soil beneath the residential building located at 481 Lock Street as this is the native material encountered on the former Ingersoll Rand site.

- The residential building located at 481 Lock Street has a basement. The USEPA default height for a basement is 200 cm (approximately 6.56 ft). However, the J&E model requires that the distance between the basement floor and the water table be at least the thickness of the capillary fringe zone, which the model calculated to be 192.31 cm (6.3 ft), based on the site-specific soil type. If the default value for a basement is used, this requirement is not met, causing the model to give an error message. Therefore, in order to allow for the capillary fringe zone, the basement height was reduced to 112.49 cm (3.69 ft).

Default values provided by NJDEP or USEPA were used for all other model input parameters. The J&E model spreadsheets for this evaluation are provided as Attachment 1.

Model Results

The J&E model provides a conservative estimate of the potential ELCR and noncarcinogenic HQ associated with inhaling TCE in indoor air that have volatilized from underlying groundwater. As documented in the attached J&E model spreadsheets, the estimated ELCR and HQ for an adult resident living at 481 Lock Street that is potentially exposed to TCE in groundwater via the vapor intrusion pathway are 1.2×10^{-7} and 6.4×10^{-5}, respectively. As recommended by NJDEP, a child inhalation adjustment factor of 0.74 should be applied to J&E modeling results to estimate potential risks to a residential child. Therefore, the potential ELCR and HQ associated with a residential child's exposure are 1.6×10^{-7} and 8.6×10^{-5}. The ELCR and HQ for the adult and child residential exposure

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[3] NJDEP. 2006. New Jersey Johnson and Ettinger Spreadsheets and Guidance. NJ-GW-SCREEN-APR06. [URL: http://www.nj.gov/dep/srp/guidance/vaporintrusion/njje.htm]. June 19, 2006.

[4] USEPA, 2004. *User's Guide for the Evaluating Subsurface Vapor Intrusion Into Buildings*. United States Environmental Protection Agency. Office of Emergency and Remedial Response. Revised February 22, 2004.

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scenarios are below the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ and below the target HQ of 1, respectively.

Risk-based groundwater concentrations for TCE were also calculated based on the upper and lower ends of USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for the modeling scenario described above. Risk-based groundwater concentrations for TCE range from 6.7 ug/L to 670 ug/L. The maximum detected concentration of TCE at 481 Lock Street (1.1 ug/L) is below this range of risk-based concentrations. The J&E model spreadsheets used to calculate the risk-based concentration are provided at the end of Attachment 1.

Uncertainty Assessment

There is some uncertainty associated with estimating potential risks from vapor intrusion to indoor air. The following factors contribute to uncertainty in the evaluation:

- The J&E model makes several conservative assumptions in estimating potential risks, which may lead to overestimating the risk. For instance, the model assumes that a compound is homogeneously distributed within the zone of contamination. Based on potable well sampling at 481 Lock Street and neighboring residences, it is clear that there is a decreasing concentration gradient from 481 Lock Street to the neighboring residences. Thus the average concentrations below the residence would be expected to be less than the maximum concentration used in the model.

- The results of this evaluation are based on the assumption that the TCE concentration in groundwater will remain constant for the assumed exposure duration (i.e., 30 years). However, it is well known in the scientific community that compounds in the environment are subject to natural attenuation and biodegradation processes. USEPA has recognized the validity and utility of natural attenuation and biodegradation as a remedial option and has published guidance for its site-specific implementation[5]. Environmental degradation has not been accounted for in the calculation of risks for the site. TCE concentrations evaluated in this report are expected to decrease over the 30 year exposure duration.

- The default basement height of 200 cm (6.56 ft) was reduced to allow sufficient space for the capillary zone thickness between the basement floor and the water table, as required by the model. Some uncertainty may be introduced by making this adjustment; however, since the potential risk estimate is well below the lower end of USEPA's target risk range, it is not likely that any uncertainty caused by this would affect the results.

- NJDEP suggests that groundwater data collected from potable groundwater wells screened at depths deeper than across the top of the water table may not be appropriate for comparison to GWSLs. In this evaluation, groundwater data collected at a depth of 48 ft bgs was evaluated. However, it is expected that VOC concentrations detected in groundwater at 48 ft bgs are similar or higher than those detected at the top of the water table due to the absence of any

[5] USEPA. 1997. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action and Underground Storage Tank Sites. EPA OSWER Directive 9200.4-17. Interim Final. December 1, 1997.

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confining unit that would limit groundwater mixing between the two depths. Therefore, it is concluded that groundwater concentrations detected at 48 ft bgs are appropriate for evaluating the potential vapor intrusion pathway.

The above uncertainties as a whole are expected to lead to an overestimation rather than an underestimation of potential risks to a resident in the building located at 481 Lock Street, as presented in this evaluation.

Conclusion and Recommendations

The results of the vapor intrusion evaluation discussed in this letter suggest that the maximum detected concentration of TCE in groundwater beneath the residence located at 481 Lock Street does not result in unacceptable risks via the vapor intrusion pathway. Therefore, no further evaluation of the vapor intrusion pathway is recommended for the residential area located beyond the southern property boundary of the site. Untreated water at this and neighboring residences will continue to be analyzed on a semi-annual basis for continued concentration trend monitoring.

If you have any questions or comments regarding the vapor intrusion investigations conducted, please feel free to call Gregg Micalizio at ENSR (732-981-0200) or Dawn Horst at Ingersoll Rand (201-573-3031).

Sincerely,

Julie A F Kabel

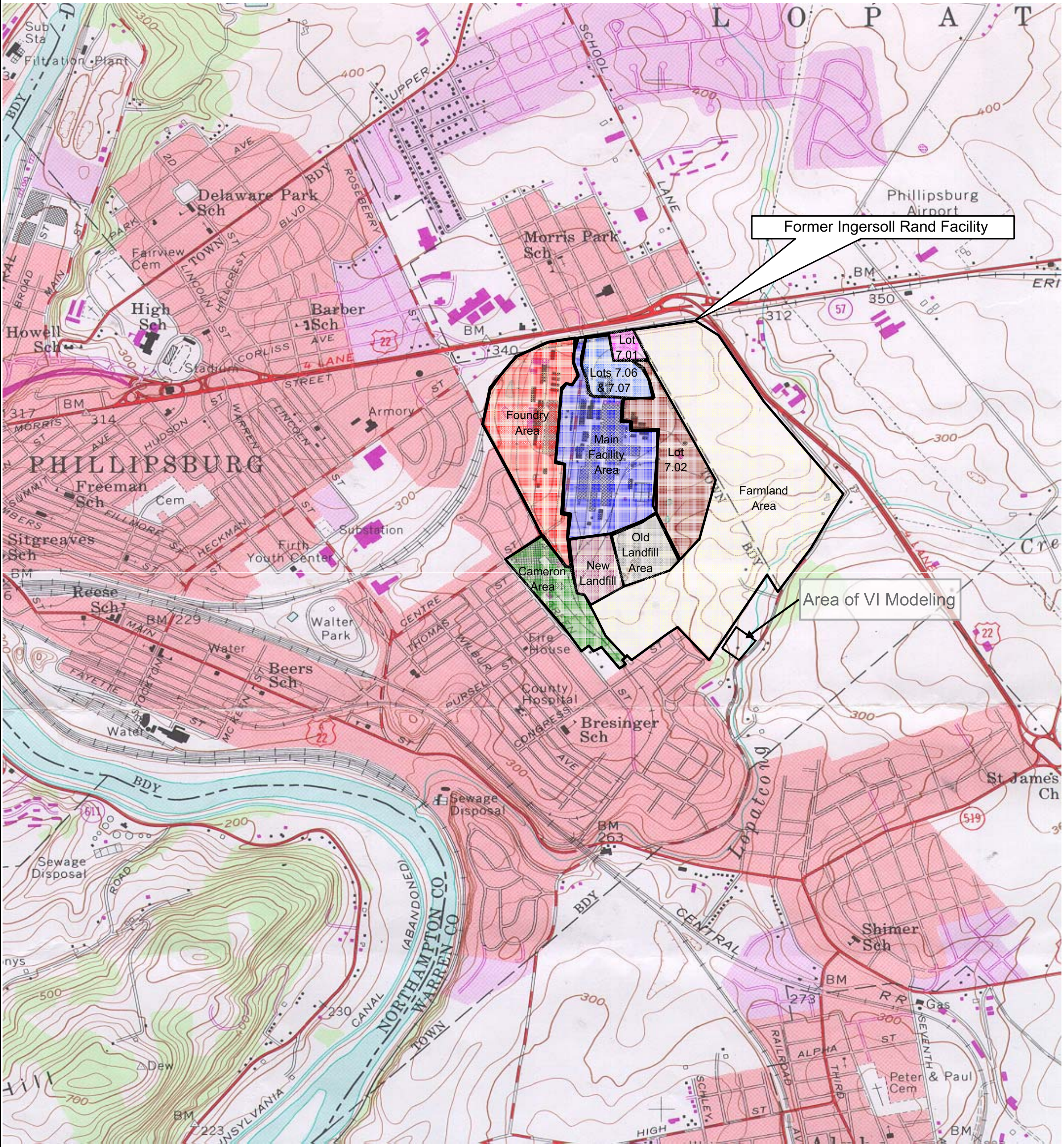
Julie Kabel, MPH
Human Health Risk Assessment Specialist

Gregg R. Micalizio
Senior Project Manager

Enclosures:

- Figure 1 – Site Location
- Attachment 1 – J&E Model Documentation

cc: Dawn Horst, Ingersoll Rand
Michele Devine (Preferred Unlimited, Inc.)
File 03710-pburg-7.2



Scale: 1:24,000	Ingersoll Rand Company Site Location Map USGS 7.5' Topographic Quadrangle-Easton, PA-NJ, 1954 (Photorevised 1981)	**Former Ingersoll Rand Facility** 942 Memorial Parkway Phillipsburg, New Jersey December 2007 Job No. 03710-176	Figure 1: Site Location Map ENSR | AECOM

ATTACHMENT 1

J&E Model Spreadsheets for the

Vapor Intrusion Modeling and Risk Evaluation at the

481 Lock Street Residence

DATA ENTRY SHEET

NJ-GW-ADV-APR06
USEPA Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
79016	1.10E+00	Trichloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
13	112.49 (3.69 ft bgs)	304.8 (10 ft bgs)	304.8	0	0	A	SIC	SIC		

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
SIC	1.38	0.481	0.216								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3$)$^{-1}$	Reference conc., RfC (mg/m^3)
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	1.66E+02	1.47E+03	1.1E-04	4.0E-02

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
9.46E+08	192.31	0.265	ERROR	ERROR	0.284	1.49E-09	0.844	1.26E-09	192.31	0.481	0.057	0.424	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
2.54E+04	1.45E+06	2.76E-04	112.49	8,520	5.62E-03	2.39E-01	1.76E-04	4.10E-03	0.00E+00	0.00E+00	3.45E-05	3.45E-05	192.31

Convection path length, L_p (cm)	Source vapor conc., C_{source} (μg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m^3)	Unit risk factor, URF (μg/m^3)$^{-1}$	Reference conc., RfC (mg/m^3)
112.49	2.63E+02	0.10	8.33E+01	4.10E-03	4.00E+02	4.40E+220	1.02E-05	2.69E-03	1.1E-04	4.0E-02

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	1.47E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.2E-07	6.4E-05

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.6E-07	8.7E-05

END

NOTE for New Jersey cases: when the risk-based indoor exposure groundwater concentration is controlled by the carcinogenic toxicity factor, the above result must be multiplied by the child inhalation adjustment factor (0.74) unless a worker scenario is being considered.
(For vinyl chloride, the factor is 0.26.)

DATA ENTRY SHEET

NJ-GW-ADV-APR06
USEPA Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
79016	1.10E+00	Trichloroethylene

MORE ↓

ENTER Average soil/groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
13	112.49 (3.69 ft bgs)	304.8 (10 ft bgs)	304.8	0	0	A	SIC	SIC		

Thickness columns: Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (°C)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (°K)	Critical temperature, T_C (°K)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc., RfC (mg/m^3)
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	1.66E+02	1.47E+03	1.1E-04	4.0E-02

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
9.46E+08	192.31	0.265	ERROR	ERROR	0.284	1.49E-09	0.844	1.26E-09	192.31	0.481	0.057	0.424	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
2.54E+04	1.45E+06	2.76E-04	112.49	8,520	5.62E-03	2.39E-01	1.76E-04	4.10E-03	0.00E+00	0.00E+00	3.45E-05	3.45E-05	192.31

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
112.49	2.39E+02	0.10	8.33E+01	4.10E-03	4.00E+02	4.40E+220	1.02E-05	2.44E-03	1.1E-04	4.0E-02

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
9.06E+00	1.71E+04	9.06E+00	1.47E+06	9.06E+00

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

Final indoor exposure groundwater conc., (µg/L)	
Target =1x10-6	Target=1x10-4
6.70E+00	6.7E+02

END

NOTE for New Jersey cases: when the risk-based indoor exposure groundwater concentration is controlled by the carcinogenic toxicity factor, the above result must be multiplied by the child inhalation adjustment factor (0.74) unless a worker scenario is being considered.
(For vinyl chloride, the factor is 0.26.)